

POLLINATION AND ITS CONTRIBUTION TO THE FRUIT PRODUCTION VALUE IN ROMANIA'S ORCHARDS IN THE PERIOD 2011-2020

Agatha POPESCU^{1,2,3}

¹University of Agronomic Sciences and Veterinary Medicine Bucharest, 59 Marasti Blvd., District 1, 011464, Bucharest Romania, Phone: +40213182564, Fax: +40213182888, Email: agatha_popescu@yahoo.com

²Academy of Agricultural and Forestry Sciences "Gheorghe Ionescu-Sisesti", 61 Marasti Blvd., District 1, 011464, Bucharest Romania, Email: agatha_popescu@yahoo.com

³Academy of the Romanian Scientists, 1 Ilfov Street, Bucharest, 030167, Romania, Email: agatha_popescu@yahoo.com

Corresponding author: agatha_popescu@yahoo.com

Abstract

The paper studied the dynamics of the economic value of pollination in Romania's orchards taking into account the main trees species producing fruits: plum, apple, cherry, apricot, pear and peach fruit trees in the period 2011-2020. The data provided by National Institute of Statistics were used to quantify fruit production and value based on the average annual purchase price, and the economic value of fruit production produced by pollinators, taking into consideration the dependence degree by fruit tree species. After a period of decline, fruit tree growing has recovered especially during the last years making investments in new plantations of apple, plum, cherry, peach trees etc. In 2020, Romania had 138,000 ha of orchards, over 74 million fruit trees, a fruit production of 1.6 million tons of which 93.33% came from the six main fruit tree species: plum (48.4%), apple (34.4%), cherry (4.6%), pear (3.09%), apricot (1.74%) and peach trees (1%). The total value of fruit production from the six species accounted for Euro 1,303.69 Million at purchase price, being by 42.2% higher than in 2011. The results proved that the pollination economic value contributed by Euro 1,032 Million, that is by about 80% to fruit production value in 2020, which reflects how important is insect pollination in fruit trees growing. In 2020, the economic value of pollination per fruit tree accounted for: Euro 12.2 for plum tree, Euro 15.7 per apple tree, Euro 13.2 per pear tree, Euro 12.4 per peach tree, Euro 26.6 per cherry tree and Euro 14.5 per apricot tree. Therefore, the entomophilous fauna has to be preserved not only for biodiversity conservation but mainly for helping the sustainable development of fruit tree growing to produce more and of higher quality.

Key words: fruit production, dependence rate on pollination, pollination economic value, dynamics, Romania

INTRODUCTION

Insect pollinators provides vital ecosystem services for sustaining agriculture and food production and for preserving plant biological diversity.

Fruit and vegetable crop production and quality depends on pollination services.

Pollination services contribute significantly to the agricultural production and its quality which assures about 75% of world food production, also to seeds spreading and plant reproduction, that is to biodiversity conservation [5, 6, 7, 9].

However, the modern agricultural technologies whose purpose is land use intensification as well as the growth of the

global population are affecting the insect pollinators and their useful services [11].

Using the data from 200 countries, Klein et al (2007) found that "fruit, vegetable or seed production from 87 of the leading global food crops is dependent upon animal pollination". Also, if we consider the volume of the world production, "60% comes from crops without dependence animal pollination, and only 35% from crops that depend on pollinators" [14].

In agriculture, pollination efficacy depends on the variety and density of entomophilous insects existing in an area, on the structure of agricultural crops, vegetables, orchards, grasslands, on the dependence degree of each crop on pollinator services and average

purchasing price of the obtained products [23].

Each crop has a different insect pollination (IP) dependency ratio (DR) as mentioned by Klein et al. (2007), and Gallai et al. (2009), who established the following yield dependence classes: *essential*, DR = 0.95 (between 90 and 100%), *great*, DR = 0.65 (40–90%), *modest*, DR = 0.25 (10–40%), and *little*, DR = 0.05 (0–10%) [5, 6, 14, 23].

In Europe there is a large variety of pollinators like: bees, butterflies, bumblebees, flies, wasps, beetles, moths and other insects with an important role for agriculture and wild flora and for maintaining biodiversity.

Among the pollinators, honey bees occupies a special role, position and attention worldwide [3, 12].

The large range of agricultural crops (sunflower, rape etc) is an important nectar and pollen source for bees [10, 16, 39, 42].

Grace to bees, the performance in crop yield, product quality and even in the shelf life and commercial value could be improved [13].

Honey bees have a special preference for the nectar pickings in the orchards of apple, apricot, cherry, plum, peach trees sustaining fruit production by their pollination services [4, 19]. The production gains varying between 80% for apple and pear trees and 30% for cherry and plum trees could be obtained grace to pollination [8, 25, 37].

Also, pollination is partially important for vegetables, while cereals, sugar beet and potatoes do not need pollination [16].

In Europe, *Apis mellifera* L. represents a peculiar species of pollinators with a special organization, work distribution among the members of the bee family, behaviour, communication relationships, and ability to transmit information about the place and position of the feed sources and their quality, and a high efficiency in pickings and producing honey for increasing the bee family power.

Spain, Greece, France, Italy, Poland and Romania have the highest number of bee colonies and hives, an aspect which is in the benefit of agriculture, beekeepers, environment and biodiversity [40].

That is why beekeeping is encouraged and financially sustained in the EU countries to increase the number of hives, bee families, apiaries, and apiculturists [40].

Bees contribution to agricultural production, biodiversity and the beauty of the landscapes reflects their importance for maintaining life on the Earth. But, we know that honey, pollen, royal jelly, propolis, venom, wax, and other wonderful products of the bee families are so important for human life. Beekeeping is a wonderful job outdoors and offering important income sources for apiculturists [26].

In Romania, beekeeping is highly developed, the number of bee colonies as well as their contribution to honey production [35, 39, 40, 41], trade [28, 31], profitability in beekeeping [27, 29, 30, 33], honey price [34], landscapes, biodiversity and environment protection and to pollination in agriculture have an ascending trend. An important growth was also carried out in fruit production [32, 36].

However, various factors such as: intensification of agriculture, the loss of habitat, reduction of feed availability, pollution, climate change, and diseases affect pollinators number [2].

Compared to the Western EU countries where agriculture is highly intensified, in Romania there is still a low intensity of farming. Studying the major pollinator groups-wild bees, hoverflies and butterflies in traditional farmlands in the Transylvanian Basin, Romania, Kovács-Hostyánszki et al (2016) found that arable fields and grasslands have abundant flower resources for sustaining pollinator communities [15, 43].

The European Parliament also adopted new regulations in order to diminish pollinators decline and also to sustain beekeeping [1, 17, 24].

In Romania there are no studies about the impact of pollination on agricultural production and biodiversity.

In this context, the paper aimed to study the economic impact of pollination in Romania's fruit production taking into consideration the main fruit trees species: plum, apple, cherry, pear, apricot and peach trees in the period 2011-2020 and using the data from National

Institute of Statistics. In fact, it was estimated the value of fruit production which is due to insect pollination services by fruit tree species, based on fruit production, dependency ratio and average annual fruit purchase price.

This paper is original being the first time when in Romania this topic is approached in the methodological manner described in the next paragraph.

MATERIALS AND METHODS

The study was based on the empirical data provided by National Institute of Statistics and Ministry of Agriculture and Rural Development for the period 2011-2020.

The following indicators were analyzed:

- Orchards surface and its distribution by fruit trees species;
- Number of fruit trees and its dynamics, trend line, regression equation, coefficient of determination and structure by species;
- Fruit production for the main six fruit trees species: plum, apple, cherry, apricot, pear and peach trees and its dynamics and structure;
- Total fruit production evolution and its trend line, regression equation and coefficient of determination;
- Fruit purchase price in Euro per ton, taking into account the average exchange rate RON/Euro in the period 2011-2020 according to National Bank of Romania;
- Dependence ratio of fruit production on pollination: 93% for cherry (average between sweet and sour cherry), 90% for apple, 70% for plum, apricot, peach and pear trees;
- Value of fruit production (FPV) at purchase price for each type of fruit, calculated according to the formula:

$$FPV = FP \times AAP \quad (1)$$

where:

- VFP is value of fruit production;
- FP is fruit production;
- AAP is the average annual purchase price of each fruit type;
- Total fruit production value (TFPV) according to the formula:

$$TFPV = \sum_{i=1}^n FPV \quad (2)$$

where $n = 6$, and represent the fruit tree species;

-Share of each fruit type in total value of fruit production;

- Economic value of insect pollination (EVIP) of the main orchards, calculated with the formula:

$$EVIP = TVFP \times D\% \quad (3)$$

where:

-TVFP is total value of fruit production;

-D% is the dependence ratio of fruit trees species on pollination.

-Total economic value of insect pollination (TEVIP) was determined with the formula:

$$TEVIP = \sum_{i=1}^n FVIP \quad (4)$$

-The dynamics of these indicators was studied using the index with fixed basis, $I_{FB} = (X_n/X_1) \times 100$, where X_1 is the level of the indicator in the year 2011 and X_n the level of the indicator in the year 2020;

-Structural indices were utilized for emphasizing the percentage contribution of each fruit trees species to the total production, total production value and total economic value of pollination.

-Graphical illustration of the dynamics pointing out the regression model and the coefficient of determination.

The results were depicted in graphics and tables and the corresponding interpretation and comments were done, and finally the main conclusions were drawn.

RESULTS AND DISCUSSIONS

Main fruit trees cultivated in Romania

Romania has a large variety of fruit plants, but the main species are represented by fruit trees, among which the most important ones are:

- *Prunus domestica* L. - the plum tree cultivated for its fruits which could be consumed as fresh fruits or processed in jams, canned, sweets, cakes and the well know Romanian brandy named "tuica";
- Malus pumila* Mill or *Malus domestica* L.- the apple tree producing the most valuable fruit for human health, which could be utilized

as fresh fruit, a real medicine, and also as dried apple or processed in soft drinks, cider, distillates, pies, cakes etc.;

-*Prunus avium* L. - sweet cherry tree and *Prunus cerasus* L. - sour cherry tree, which are well known for their delicious fruits which could be consumed as fresh fruits, but also like industrialized fruits: candied, frozen and canned cherries, jams, soft drinks, alcoholic drinks (cherry brandy, liqueurs), syrups, pies, cakes, ice-cream, sherbet, spump, souffle, salads, sauces;

-*Prunus communis* L. - the pear tree produces wonderful sorts of fruits which are preferred to be consumed fresh or processed in canned fruits and juice;

-*Prunus armenica* L.- the apricot tree provides tasty and flavoured fruits used as fresh fruits or processed in jams, liqueur, juice or included in biscuits and cakes;

-*Prunus persica* L.- the peach tree produces juicy and flavoured fruits which could be consumed as such or in jams and juices.

All these fruit trees are pollinated by various insects, but especially by honey bees.

Cultivated area with fruit trees

According to Ministry of Agriculture and Rural Development, in 2018, the apple trees plantations were situated on the top position covering 53,900 ha (39.2%), the plum trees orchards had 53,400 ha (39.1%) and 30,000 ha were cultivated with other species (cherry, pear, apricot, peach, nut trees etc, all of them summing 137,300 ha. But, this area was by 5.5% smaller than 145,300 ha in 2009 [20].

In 2019, the same surface like in 2018 included about 47% (64,530 ha) plum trees and 40% (55,000 ha) apple trees, and the remaining of 13% belonged to other species.

Romania is on the top position in the EU for its surface covered by orchards of plum trees and on the 2nd position for the area of the apple trees orchards.

In 2020, Romania reached 138,000 ha fruit trees plantations, therefore it was recorded a slight increase of 0.5% in new plantations [21].

In 2020, Romania had 6,780 ha cultivated with cherry trees, by 10% more than in 2016

and representing 4.9% of the orchards area. The growth of the surface was due to the interest of the growers for cherry trees whose technologies are simple, production is high and the market price is good [18].

Also, in 2020, the pear trees were cultivated on about 3,250 ha, apricot trees on 2,370 ha and peach trees on about 1,700 ha (Fig. 1).

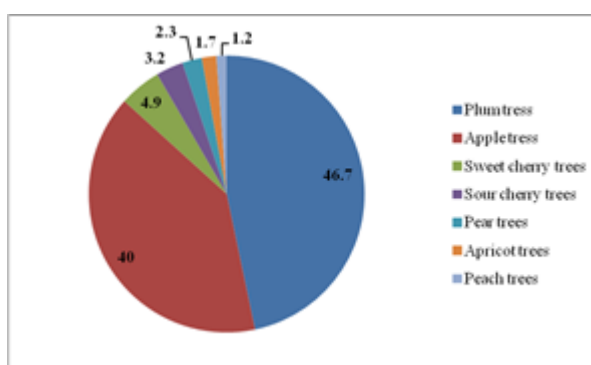


Fig. 1. The share of the fruit trees in the orchards surface in 2020, Romania (%)

Source: Own design based on the data from [22].

Number of fruit trees

In Romania, in the period 2011-2020, the number of fruit trees registered a general decreasing trend from 85,741,132 trees in 2011 to 74,059,510 trees in 2020, meaning by 13.63% less in the last year of the interval compared to the first year (Fig. 2).

In fact, after the year 1990, the orchards were facing a severe degradation, just a few investments were made in new plantations, the fruit trees growers were lacked of labour force for maintaining the plantations, climate change affected the orchards at blooming or at fruit maturity or harvesting, causing production losses and fruit quality was diminished.

Only during the last year, new plantations were installed especially for apple trees, cherry and peach trees.

As a result, the main accent was done on these three species and a weak attention was given to the other sorts of trees: pear, apricot and peach trees.

In consequence, fruit production declined and at present, import is required to cover consumption needs in the domestic market.

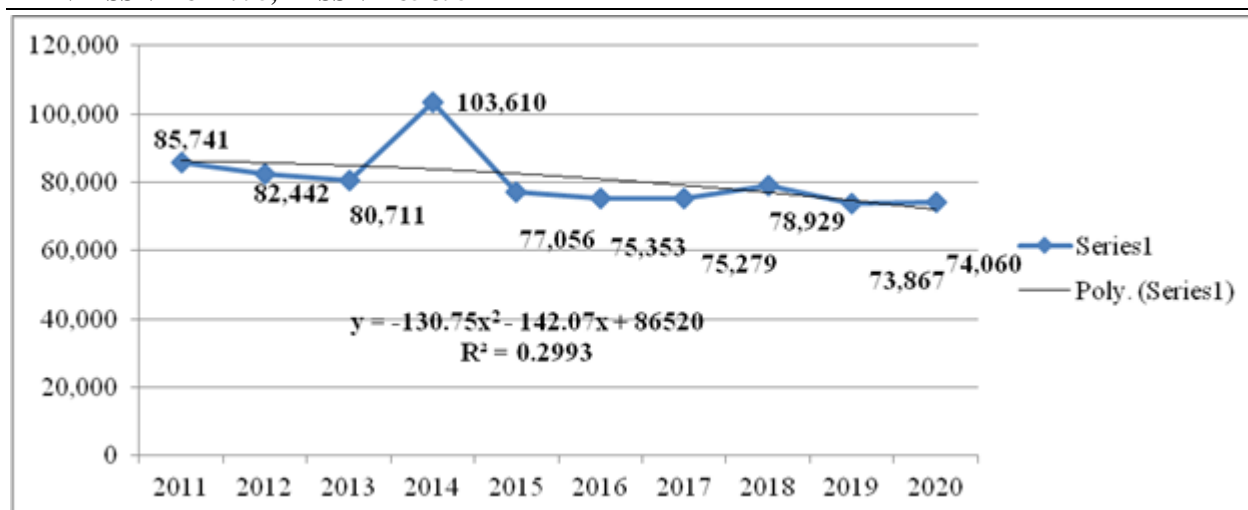


Fig. 2. Number of fruit trees in Romania, 2011-2020
Source: Own design based on the data from [22].

In 2020, the highest share in the total number of fruit trees belonged to plum trees, 46.48%, and apple trees, 32.70%, the both species summing 79.18%.

From a numerical point of view, on the next positions came sweet and sour cherry trees with a share of 7.26%, pear trees with 4.46%, apricot trees 2.8% and peach trees 1.47%.

All these six species together represent 95.17% in the total number of fruit trees, and the remaining of 4.83% belongs to nut and hazelnut trees etc (Fig. 3).

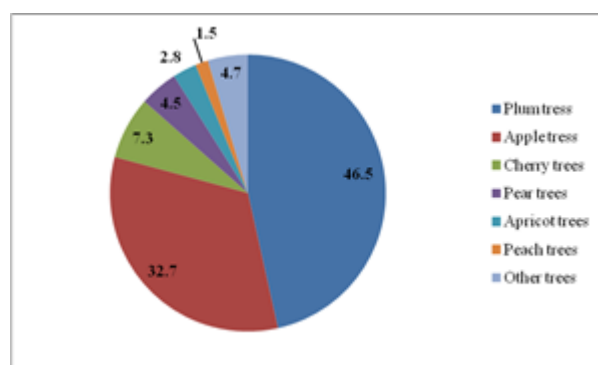


Fig. 3. Share of various fruit trees species in the total number of fruit trees, Romania, 2020 (%)
Source: Own design based on the data from [22].

Fruit production

Fruit production in Romania registered a slight increase of only 8.17% during the last decade. In 2020, it reached 1,601 thousand tons in comparison with 1,480 thousand tons in 2011. This happened because during the last year new plantations were set up using EU funding. Of the total production, 837

thousand tons, meaning 52.27%, came from six fruit trees selected in this study: plum, apple, cherry, pear, apricot and peach trees [21] (Fig. 4).

However, the level recorded in 2020 was by 11.72% lower than in 2018, when Romania reached the highest fruit production in the last decade, accounting for 1,813 thousand tons.

In the production structure, plums had the share of 46.4%, apples 35.5%, summing 81.9%, and the remaining of 18.1% belonged to cherries (5%), pears (3.3%), apricots (2%), peaches (1.2%), and strawberries (1.4%).

The data from Figure 4 showed variations in fruit production from a year to another, the lowest and critical level was 1,058 thousand tons registered in the year 2017 and also 1,129 thousand tons recorded in 2012, and the highest performance was 1,913 thousand tons in 2018, the most favourable year. Also, after a decline to 1,487 thousand tons in 2019, fruit production was better in 2020 accounting for 1,601 thousand tons.

The annual changes were determined by the variations in the number of trees and climate conditions.

As a result, the production structure changed from 2011 to 2020, especially regarding apple and plum trees. If in 2011, on the top position came apple output with a share of 41.92%, in 2020, it was ranked the 2nd with 34.43%. the plums contributed by 38.75% to fruit output in 2011, but in 2020 they passed on the 1st position with 48.43%.

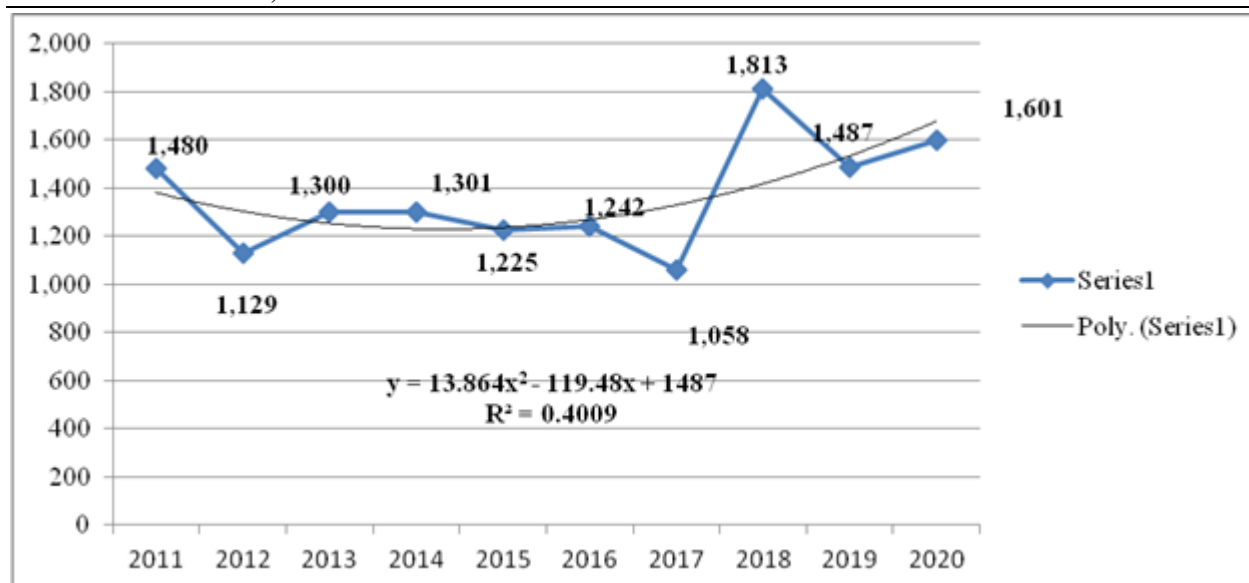


Fig. 4. Dynamics of fruit production, Romania, 2011-2020 (Thousand tons)
Source: Own design based on the data from [22].

This situation is explained by the structure of the fruit trees, where the plum trees are more numerous than apple trees as Romanians like to consume not only fresh plums or jam, but mainly "tuica", the traditional plum brandy. The share of cherries, pears, apricots and peaches declined in favour of other fruits (Table 1).

Table 1. Structure of fruit production by fruit type, Romania, 2020 versus 2011 (%)

	2011	2020
1.Plums	38.75	48.43
2.Apples	41.92	34.43
3.Cherries (sweet and sour)	5.53	4.64
4.Pears	4.52	3.09
5.Apricots	2.28	1.74
6.Peaches	1.42	1.00
Total, 1+2+3+4+5+6	94.42	93.33
7.Other fruits	5.58	6.67
TOTAL	100.00	100.00

Source: Own calculation based on the data from [22].

Table 2. Fruit purchase price per fruit type, Romania, in 2020 versus 2011 (Euro/Ton)

	Apple	Plum	Cherries	Apricots	Pears	Peaches
2011	618.2	547.4	1,240.0	1,071.2	953.3	844.7
2020	766.9	775.2	2,068.3	1,542.2	1,267.3	1,230.0
2020/2011 %	124.0	141.6	166.7	143.9	132.9	145.6

Source: Own calculation based on the data from [22].

Fruit production value

The value of fruit production (FPV) resulted from multiplying fruit production by average annual purchase price for each type of fruit.

Fruit purchase price

An ascending trend was noticed regarding fruit purchase price in the analyzed interval. Compared to the level in 2011, in 2020, the average annual purchase price was higher by 66.7% for cherries, 45.6% for peaches, 43.9% for apricots, 41.6% for plums, 32.95 for pears and 24% for apples.

In 2020, by fruit type and in the decreasing order, price level was: cherries, apricots, pears, peaches, plums and apples.

Nevertheless, fruit price is strongly correlated with fruit production. In the years when production was high, average purchase price was lower, while in the years with a low production and a high demand, fruit price was high.

Of course, fruit price depends on fruit type and consumer preferences as well as on changes in the domestic and external market (Table 2).

Summing the value of fruit production from the all six fruits considered in this study as being the most important, in 2020, the total value of fruit production (TFPV) accounted

for Euro 1,303.69 Million, being by 42.20% higher than in 2011, when it was Euro 422.93 Million (Table 3).

Table 3. Fruit production value (FPV) for the selected six fruits, Romania, 2011-2020 (Euro Million)

	Apples	Plums	Cherries	Apricots	Peaches	Pears	Total (TFPV)
2011	383.51	313.99	101.48	36.14	17.87	63.79	916.78
2012	278.41	246.47	111.60	28.85	15.87	51.03	732.23
2013	324.22	271.35	109.81	26.90	17.22	63.23	812.73
2014	317.51	278.60	115.51	40.72	19.94	67.84	840.12
2015	294.53	283.68	99.45	34.31	18.08	46.67	776.72
2016	290.31	287.83	111.71	34.21	19.86	57.32	801.24
2017	226.66	327.24	93.57	31.64	15.67	55.74	750.52
2018	444.13	515.72	131.57	42.81	23.04	66.62	1,223.89
2019	311.79	527.27	157.72	33.84	18.10	59.80	1,108.52
2020	422.93	601.26	154.00	43.13	19.53	62.84	1,303.69
2020/2011 %	110.27	191.49	151.75	119.34	109.28	98.51	142.20

Source: Own calculation.

The contribution of the main fruit trees species to the fruit production value was the following one in 2020: plums 46.11%, apples 32.44%, summing 78.55%, and being followed by cherries with 11.81%, pears 4.82%, apricots 3.3% and peaches 1.51% (Fig. 5).

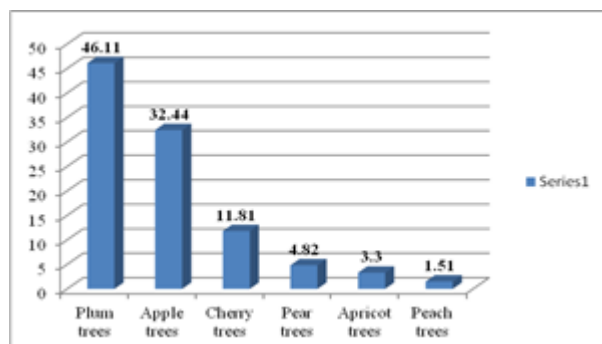


Fig. 5. The contribution of fruit type to the total fruit production value in 2020 (%)

Source: Original design and calculation.

Economic value of insect pollination for the six selected fruit trees species

For calculating the economic value of insect pollination (EVIP) for each of the six selected fruit trees species, there were taken into consideration the fruit production value (FPV) and the dependence ratio ($D\%$) of production on the pollinating insects as mentioned at the methodological aspects: 93% for cherry, as an average between sweet and sour cherry, 90%

for apple and 70% for plum, apricot, peach, and pear trees.

In 2020, TFPV accounted for Euro 1,032.59 Million, being by 39.2% higher than Euro 741.78 Million registered in 2011.

Versus 2011, in 2020, the contribution of the pollinators to the economic value of fruit production was higher by 91.49% for plums, 51.75% for cherries, 19.33% for apricots, 10.28% for apples, 9.27% for peaches and by 1.485 lower for pears (Table 4).

Also, in 2020, the share of EVIP for each fruit type in the total TEVIP was the following one: plums 40.75%, apples 36.86%, cherries 13.86%, pears 4.26%, apricots 2.92% and peaches 1.35% (Fig. 6).

As a result, the contribution of insect pollination to TEVIP in 2020 accounted for 79.20% compared to 80.91% in 2011, the difference being very small of just -1.71%. Therefore, we may consider that, in average, about 80% of the total value of fruit production is given by pollination.

Taking into account the surface covered by the orchards of the six selected main fruit trees species accounting for 138,000 ha in 2020, the value of fruit production given by pollination was Euro 7,482.5 per ha in average.

Table 4. Economic value of insect pollination (EVIP) for the selected six fruits, Romania, 2011-2020 (Euro Million)

	Apples	Plums	Cherries	Apricots	Peaches	Pears	Total (TEVIP)
2011	345.15	219.79	94.38	25.30	12.51	44.65	741.78
2012	250.56	172.53	103.79	20.19	11.11	37.52	593.90
2013	291.79	189.94	102.12	18.83	12.05	44.26	658.99
2014	285.75	195.02	107.42	28.50	13.96	47.49	668.14
2015	265.07	198.58	92.49	24.02	12.65	32.67	625.48
2016	261.28	201.48	103.89	23.95	13.90	40.12	644.62
2017	203.99	229.07	87.02	22.14	10.97	39.02	592.21
2018	399.72	361.00	122.36	29.97	16.13	46.63	975.81
2019	280.61	369.09	146.67	23.69	12.67	41.86	874.59
2020	380.64	420.88	143.22	30.19	13.67	43.99	1,032.59
2020/2011 %	110.28	191.49	151.75	119.33	109.27	98.52	139.20

Source: Original calculation.

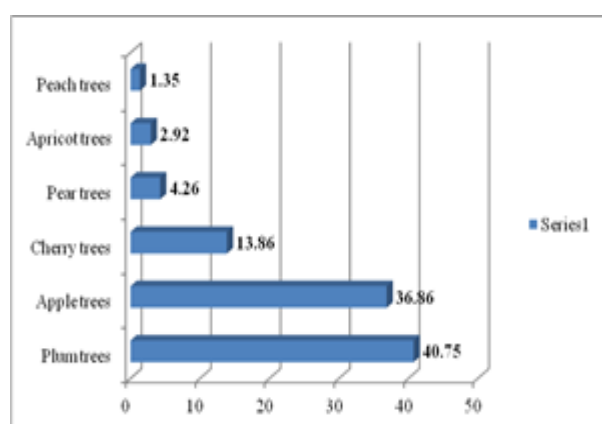


Fig. 6. The share of each trees species in the total economic value of the insect pollination (TEVIP) in 2020 (%)

Source: Original design and calculation.

By fruit tree species and per ha of orchard, the economic value of pollination was in 2020 the following one: plum tree 6,522 Euro/ha, apple tree 6,921 Euro/ha, cherry tree 12,845 Euro/ha, pear tree 13,535 Euro/ha, peach tree 8,041 Euro/ha and apricot tree 12,738 Euro/ha.

By fruit tree species, taking into account the number of fruit trees in the year 2020, it could be concluded that the economic value of pollination accounted for: Euro 12.2 per plum tree, Euro 15.7 per apple tree, Euro 13.2 per pear tree, Euro 12.4 per peach tree, Euro 26.6 per cherry tree and Euro 14.5 per apricot tree (Table 5).

Table 5. Pollination economic value per ha of orchard and per tree by fruit tree species in Romania, 2020

Economic value of pollination	Apple tree	Plum tree	Cherry tree	Apricot tree	Peach tree	Pear tree
Euro/ha	6,921	6,522	12,845	12,738	8,041	13,535
Euro/tree	15.7	12.2	26.6	14.5	12.4	13.2

Source: Original calculation.

CONCLUSIONS

The results of this study proved that the contribution of the entomophilous species to fruit production must not be denied.

This shows how important are insects in helping the farmers for obtaining a high performance in fruit trees growing and not only, if we consider that in Romania there are cultivated many agricultural crops and also the wild flora need to be pollinated.

Pollination made by various insects, especially by honey bees sustains vegetal production and also the wild flora to

perpetuate and develop and preserve biodiversity both in the flora and insect fauna world.

The economic value of pollination in the fruit trees plantations depends on fruit tree species, the number of fruit trees, the structure of orchards and their area, the dependence ratio of fruit production on the activity of the insects, and also on the climate conditions, production technologies and performance, average annual purchase price of fruits in the domestic market.

The analysis in the period 2011-2020 showed that pollination contributed by Euro 1,032,59

Million to the value of fruit production which accounted for Euro 1,303.69 Million in 2020. Therefore, about 80% of the economic value of fruit production is achieved due to the activity of the insects.

The value of pollination per ha and per tree differs from a fruit tree species to another, but it is important for farmers to know which are the advantages from a quantitative point of view for increasing production performance and fruit quality and for getting a higher selling price and satisfy better consumer needs.

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